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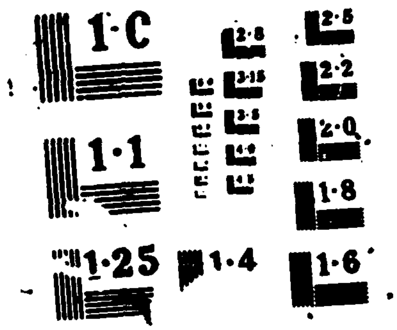

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SPALLATION AND DYNAMIC FRACTURE AS AN EFFECT OF LASER-INDUCED SHOCK-WAVES

Second Periodic Report

David Salzmann and Irith Gilath

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Spallation and Dynamic Fracture as an Effect of Laser Induced Shock Waves

D. Salzmann, I. Gilath, S. Maman and Y. Sapir

The main activities during the last four months of this contract were devoted to a detailed design of the mainstream of the experiments and the purchase of carbon-carbon composite targets with appropriate specifications for these experiments. Some preliminary experiments were carried out on 3D C-C targets to get some initial quantitative information about the range of laser intensities required to cause damage to these targets.

(1) Targets Materials

1.1 Graphite-epoxy targets

Graphite-epoxy targets will be used in one series of experiments. These targets were obtained in foils of 450 μm thickness. Thin protective cloth covers the foil and we intend to measure the damage thresholds with and without this protection. The targets are composed of three layers of epoxy reinforced by graphite fibers. The fiber orientation in neighboring layers is perpendicular to each other.

1.2. Two-dimensional carbon-carbon composites

High quality carbon-carbon composites were ordered , and are expected to arrive in the near future.

The choice of these materials as target foils for our experiments was influenced by their exceptional properties. In fact, carbon fibers are characterized by high strength and stiffness to weight ratios, low density, good friction and wear properties, good fatigue and creep resistance, dimensional stability and good vibrational damping properties. Carbon fibers are chemically inert to most reagents (except strong oxidizing agents) and composites made with them show good stress corrosion and wear resistances. In view of these properties , these materials found extensive use in aerospace applications.

The targets that have been purchased are composed of three layers of 10 µm carbon fibers. The fiber orientation in neighboring layers is perpendicular to each other. The central layer is about 300 µm, the two outer layers are thinner, to give a total foil thickness of 500µm. On the basis of our experience with graphite-epoxy (first report) and 3D carbon-carbon composite targets (see below) , we expect that our laser system can deliver enough energy to produce shock pressures which are high enough to damage targets having this thickness. The specific gravity of the first batch of targets is around 1.6 g/cm^3, and will be measured more accurately upon their receipt.

1.3 Three-dimensional carbon-carbon composites

We received two small samples of three-dimensional carbon-carbon composite targets, having thicknesses of 430 and 810 μm. The targets are composed of two layers of 10 μm diameter carbon fibers which are parallel to the foil surface and, perpendicular to each other, and fibers in groups of about 1mm diameter aligned perpendicular to these layers. The samples were too small in area to allow for a systematic study of their properties, but the few laser shots made on the targets provided some interesting results (see below).

We hope to receive more samples of this kind in the future. We plan to carry out a systematic study of their properties under the very high strain rates induced by laser-driven shock waves.

(2) Experiments with 3D C-C composites

The main aim of these experiments was to find some rough limits on the threshold of laser induced damage in carbon-carbon composites. SEM photographs of the results are shown in figures 1-4.

As expected, we have found a growing damage pattern on the backsurface with increasing laser irradiance.

The 430 μm thick target was irradiated with laser pulses having energies from 12J ($I=7.10^{10}W/cm^2$) up to 68J ($I=4.10^{11}W/cm^2$). While for the lower energy only some slight damage could be observed on the backsurface (Fig. 1), at the highest energy the target was perforated by the front and backsurface cratering due to the laser and the shock wave interactions, Fig.2.

The 810 um thick target revealed similar behavior. This target was irradiated by laser energies between 53J and 83J ($I=3-5.10^{11} W/cm^2$). While backsurface damage could be observed even in the lower of these irradiation levels this thicker target could not be perforated by an 83J laser pulse (Fig. 3).

The microstructure of a damaged area is shown in figure 4. This damage pattern is presently under further analysis.

(3) Future Plans

During the next months a sequence of experiments will be carried out on 2D C-C composite and graphite epoxy targets. The main aim of this sequence is to characterize the generated damage , first in qualitative terms. and later to measure more accurately the damage thresholds.

As a next step, we intend to purchase C-C composites of varying specific gravity, and measure the damage thresholds of the targets as function of their specific gravity. As all the mechanical properties of C-C composites strongly depend on the specific gravity , such a measurement will yield very valuable results.

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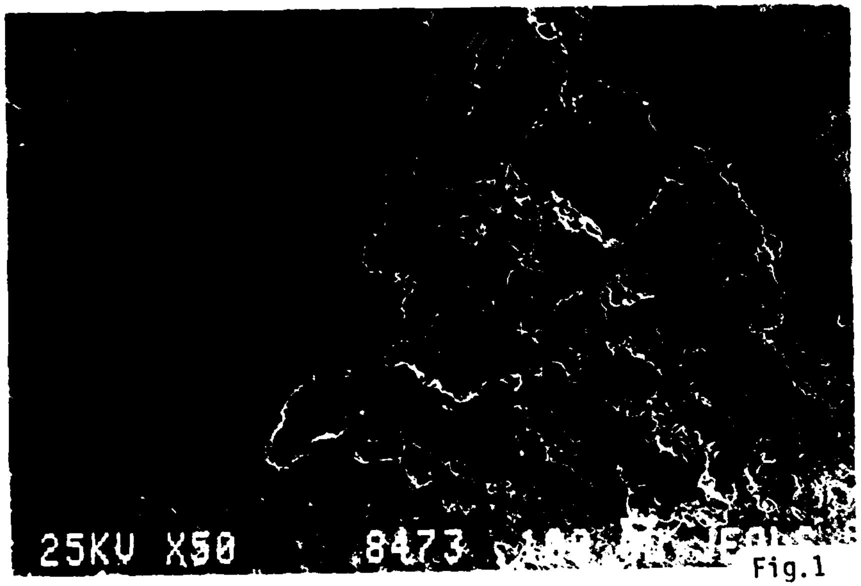

Fig.1

Fig. 3

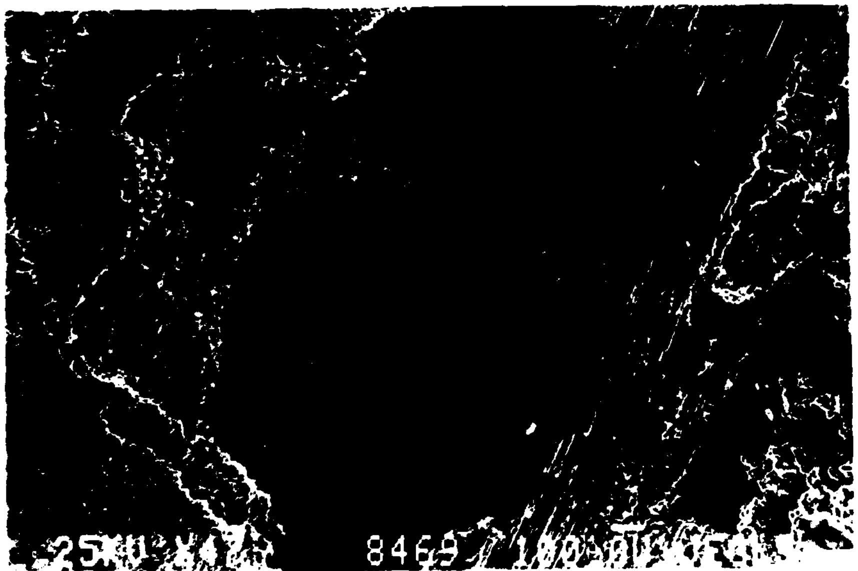

Fig.2

Fig. 4

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